
UNIVERSITI SAINS MALAYSIA

First Semester Examination
2015/2016 Academic Session

December 2015 / January 2016

EAG245 – Soil Mechanics
[Mekanik Tanah]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **FIFTEEN (15)** pages of printed material including **ONE (1)** appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **LIMA BELAS (15)** muka surat yang bercetak termasuk **SATU (1)** lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.
[Arahan : Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.]

All questions **MUST BE** answered on a new page.
*[Semua soalan **MESTILAH** dijawab pada muka surat baru.]*

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

1. [a] Soils are formed from weathering of rocks and can be grouped according to their origins such as residual soil, alluvium and colluvium. The nature of the parent rock normally influences the soil properties such as texture, porosity and mineralogy. Therefore, it is important to distinguish the engineering characteristics between residual soil and colluvium soil especially along the slope.

Tanah terbentuk hasil dari proses luluhawa batuan dan dapat dikumpulkan berdasarkan kepada asalannya seperti tanah sisa, aluvium dan kolovium. Jenis batuan induk selalunya mempengaruhi sifat-sifat tanah tersebut seperti tekstur, keliangan dan mineral. Oleh sebab itu, amat penting untuk membezakan ciri-ciri kejuruteraan di antara tanah sisa dan kolovium terutamanya di sepanjang cerun.

- [i] Explain the main characteristics and differences between colluvium and residual soils.

Jelaskan ciri-ciri utama dan perbezaan diantara kolovium dan tanah sisa.

[4 marks/markah]

- [ii] With the help of a sketch, draw the typical cross section of slope showing the possible location of colluvium and residual soil.

Dengan berbantuan lakaran, lukis keratan rentas cerun yang tipikal dan tunjukkan kedudukan yang mungkin bagi kolovium dan tanah sisa.

[4 marks/markah]

- [b] A soil sample obtained at the Earth Dam site in Hulu Terengganu Hydroelectric Power Scheme has a bulk unit weight of 18.5 kN/m^3 at water content of 13.5%.

Sampel tanah yang diperolehi dari tapak pembinaan empangan tanah di Skim Projek Hidroelektrik, Hulu Terengganu mempunyai berat unit pukal 18.5 kN/m^3 pada kandungan air 13.5%.

- [i] Draw the phase diagram for the soil and derive the necessary equations for each phase based on the weight-volume relationship (Assume $V_s = 1$).

Lakarkan gambar rajah fasa bagi tanah tersebut dan terbitkan persamaan yang perlu bagi setiap fasa berdasarkan kepada hubungan berat-isipadu (Andaikan $V_s = 1$).

[6 marks/markah]

- [ii] Determine the soil void ratio, degree of saturation and volume of air voids. (Assume $G_s = 2.65$)

Tentukan nisbah rongga, darjah ketepuan dan isipadu rongga udara tanah tersebut (Andaikan $G_s = 2.65$).

[6 marks/markah]

2. [a] A fall cone test was carried out on the clay obtain at the Aman Central construction site in Alor Setar, Kedah. The result of the test is given in **Table 1**.

*Ujian 'Fall Cone' telah dijalankan terhadap lempung yang diperolehi dari tapak pembinaan Aman Sentral di Alor Setar, Kedah. Keputusan ujikaji tersebut diberikan di **Jadual 1**.*

Table 1 / Jadual 1

Penetration/ <i>Penusukan</i> (mm)	9	14	20	31	39
Water content/ <i>Kandungan air</i> (%)	44.1	51.5	57.3	64.5	68.7

- [i] Determine the liquid limit of the soil

Tentukan had cecair tanah tersebut.

[4 marks/markah]

- [ii] If the plastic limit of the soil is 26.5%, determine the plasticity index of the soil.

Jika had plastik tanah tersebut 26.5%, tentukan indeks keplastikan tanah tersebut.

[2 marks/markah]

- [b] The sieve analysis of soil taken from a new condominium project site at Amansuri Residence, Alor Setar, Kedah is given in **Table 2**.

*Analisis ayakan tanah yang diperolehi dari tapak projek kondominium Amansuri Residence, Alor Setar, Kedah diberikan di **Jadual 2**.*

Table 2 / Jadual 2

US Sieve No. No. Ayakan US	Sieve Size/ Saiz Ayakan (mm)	Weight Retained / Berat Tertahan (g)
4	4.75	0
10	2	50
20	0.85	70
40	0.425	90
60	0.25	140
80	0.18	122
100	0.15	210
200	0.075	56
Pan	-	12

- [i] Plot the grain size distribution curve from the sieve analysis given in **Table 2**.

*Plot lengkung agihan saiz butiran daripada analisis ayakan yang diberikan di **Jadual 2**.*

[6 marks/markah]

- [ii] Calculate the Uniformity coefficient, C_u and Coefficient of Curvature, C_c of the soil.

Kirakan pekali keseragaman, C_u dan pekali kelengkungan, C_c tanah tersebut.

[4 marks/markah]

- [iii] Classify the soil by using the Unified Soil Classification System (USCS) **(Refer to Appendix)**

*Kelaskan tanah tersebut dengan menggunakan Unified Soil Classification System (USCS) **(Rujuk Lampiran)***

[4 marks/markah]

3. Continuous water resource is very important for urban water supply and in order to meet population growth demand, a ground water resource has been proposed for water supply. The site investigation has been conducted for this project, and a confined aquifer was found 20 meter below the ground level as shown in **Figure 1**. The ground water table is located at 8 meter below the ground level.

*Sumber air berterusan adalah sangat penting bagi bekalan air dan untuk memastikan bekalan yang cukup berdasarkan perkembangan populasi, sumber air bawah tanah telah dicadangkan sebagai bekalan air. Penyiasatan tapak telah dijalankan bagi projek ini, dan akuifer tertutup telah dijumpai pada kedalaman 20 meter dari permukaan tanah seperti ditunjukkan dalam **Rajah 1**. Aras air bumi berada pada kedalaman 8 meter di bawah permukaan tanah.*

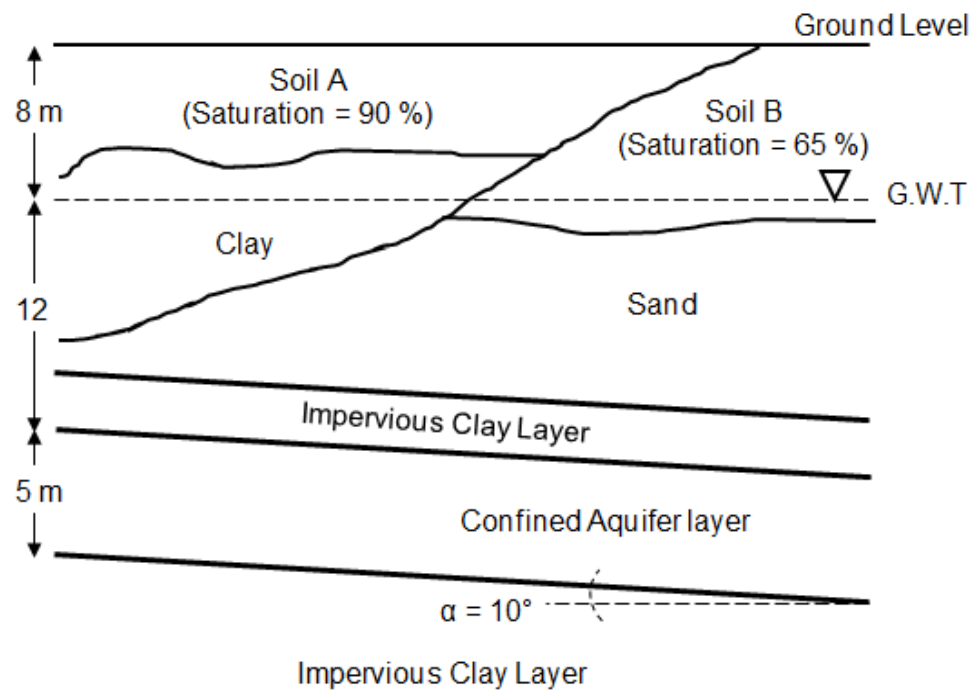


Figure 1 / Rajah 1

- [a] The factors affecting soil permeability include degree of saturation (S) and type of the soil.

Faktor-faktor yang mempengaruhi ketelapan tanah termasuk darjah ketepuan (S) dan jenis tanah.

- [i] Discuss **ONE (1)** mechanism that contribute to the higher soil permeability of Soil A ($S = 90\%$) compared to Soil B ($S = 65\%$).

*Bincangkan **SATU (1)** mekanisma yang menyumbang kepada ketelapan tanah yang tinggi bagi Tanah A ($S = 90\%$) berbanding dengan Tanah B ($S = 65\%$).*

[3 marks/markah]

- [ii] Discuss **ONE (1)** mechanism that contribute to the higher soil permeability of sand layer compared to clay layer.

*Bincangkan **SATU (1)** mekanisma yang menyumbang kepada ketelapan tanah yang tinggi bagi lapisan pasir berbanding dengan lapisan tanah lempung.*

[3 marks/markah]

- [b] During soil investigation, a soil sample was taken from the aquifer and it is found that the sample consists of fine grain soil. Suggest a suitable permeability test and provide your justification.

Semasa penyiasatan tanah dilakukan, sampel tanah telah diambil daripada akuifer dan sampel tersebut didapati mempunyai tanah butiran halus. Cadangkan ujian kebolehtelapan yang sesuai dengan justifikasi pemilihan ujian tersebut.

[2 marks/markah]

- [c] Prove that the hydraulic gradient, i of the given aquifer layer in **Figure 1** is $\sin \alpha$.

*Buktikan kecerunan hidraulik, i bagi lapisan akuifer yang diberikan di **Rajah 1** adalah $\sin \alpha$.*

[2 marks/markah]

- [d] Calculate the flow rate in $\text{m}^3/\text{sec}/\text{m}$ length through the aquifer layer if the hydraulic conductivity is $5 \times 10^{-3} \text{ cm/s}$.

Kira kadar alir dalam $\text{m}^3/\text{sec}/\text{m}$ panjang melalui lapisan akuifer sekiranya diberi kekonduksian hidraulik adalah $5 \times 10^{-3} \text{ cm/s}$.

[6 marks/markah]

...8/-

- [e] Given the hydraulic conductivity of sand is 7×10^{-3} cm/sec and the viscosity of water at 25°C is 0.0789×10^{-4} g.sec.cm². Calculate the absolute permeability \bar{K} of the sand.

Diberikan kekonduksian hidraulik bagi pasir adalah 7×10^{-3} cm/sec dan kelikatan air pada 25°C adalah 0.0789×10^{-4} g.sec.cm². Kira kebolehtelapan mutlak \bar{K} bagi pasir tersebut.

[4 marks/markah]

4. In general, soil consists of solid particles which are distributed randomly and with void spaces occupied by water and/or air in between. Under the ground surface, there are several types of stresses acting on the soil solid particles and the void spaces, such as total stress and effective stress. Explain the main differences between total stress and effective stress using the equations expressing these two parameters and with the help of the free body diagram of the soil profile.

Secara umum, tanah mengandungi zarah pepejal yang bertaburan secara rawak dengan ruang lompong yang diisi oleh air dan/atau udara diantaranya. Di bawah permukaan tanah, terdapat beberapa jenis tegasan yang bertindak terhadap zarah pepejal dan ruang lompong tanah seperti tegasan jumlah dan tegasan berkesan. Jelaskan perbezaan utama di antara tegasan jumlah dan tegasan berkesan melalui persamaan untuk kedua-dua parameter tersebut dan dengan berbantuan lakaran gambarajah jasad bebas untuk profil tanah.

[6 marks/markah]

- [a] Based on the soil investigation at the new highway construction site, a soil profile with initial groundwater table at 1.2 m is given in **Figure 2**.

*Berdasarkan kepada penyiasatan tanah di tapak pembinaan lebuh raya baru, profil tanah dengan paras airbumi awal pada kedalaman 1.2 m diberikan di **Rajah 2**.*

- [i] Plot the variations of total stress, pore pressure and effective stress with depth for the soil profile given in **Figure 2**.

*Plotkan variasi tegasan jumlah, tekanan liang dan tegasan berkesan dengan kedalaman untuk profil tanah yang diberikan di **Rajah 2**.*

[8 marks/markah]

- [ii] Assuming that the groundwater table has lowered down from 1.2 m to 2.5 m and therefore a zone of capillary rise is formed between 1.2-2.5 m, calculate the effective stress at depth of 1.2 m and 2.5 m (Given: Degree of saturation, $S = 40\%$, Specific gravity, $G_s=2.7$ and Void ratio, $e=0.65$).

Dengan mengandaikan aras air bumi telah menurun dari kedalaman 1.2 m kepada 2.5 m dan menyebabkan zon kenaikan rerambut terbentuk di antara kedalaman 1.2-2.5 m, kira tegasan berkesan pada kedalaman 1.2 m dan 2.5 m (Diberi: Darjah ketepuan, $S = 40\%$, Graviti tentu, $G_s=2.7$ dan Nisbah lompong, $e=0.65$).

[6 marks/markah]

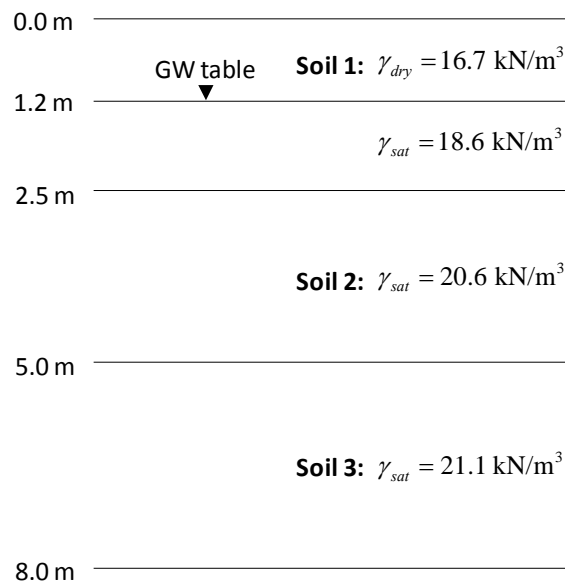


Figure 2 / Rajah 2

5. A compaction work is conducted for a hospital project in a 49 hectare area. The result of the standard compaction for the sample taken from the site is shown in **Table 3**.

*Kerja pepadatan dilakukan bagi projek hospital meliputi kawasan 49 hektar. Keputusan ujian pepadatan piawai bagi sampel yang diambil daripada tapak pilihan diberikan di **Jadual 3**.*

Table 3 / Jadual 3

Bulk Unit Weight (kN/m ³)/ <i>Berat Unit Pukal (kN/m³)</i>	17.5	18.5	21.0	20.5	20.0
Water Content (%)/ <i>Kandungan Air (%)</i>	10.0	12.5	15.0	17.5	20.0

- [a] Explain **TWO (2)** drawbacks for having soil not properly compacted and state the type of soil that does not respond well to compaction.

*Terangkan **DUA (2)** kemudaratan dipunyai oleh tanah yang tidak dipadatkan dengan betul dan nyatakan jenis tanah yang tidak bertindak balas baik dengan pepadatan.*

[4 marks/markah]

- [b] In a compaction work, the quality has been controlled by a soil testing program. The dry unit weight of the current compacted soil is 16.8 kN/m³. If the soil needed to be compacted to at least 95% of standard maximum dry density, determine whether the current compaction has met the requirement.

Semasa kerja pepadatan, kualiti telah dikawal melalui program ujian tanah. Berat unit kering bagi tanah yang telah dipadatkan sehingga kini adalah 16.8 kN/m³. Sekiranya tanah tersebut perlu dipadatkan sekurang-kurangnya 95% ketumpatan kering maksimum piawai, tentukan samaada pepadatan semasa telah mencapai keperluan.

[10 marks/markah]

- [c] Explain **TWO (2)** methods of obtaining dry unit weight by field test.

Terangkan DUA (2) kaedah bagi mendapatkan berat unit kering melalui ujian tapak.

[6 marks/markah]

6. [a] Consolidation is one of the normal phenomena for the fine grain or cohesive soil under certain loading conditions. Explain characteristics and the methods used to evaluate **THREE (3)** most important consolidation parameters which are:-

Pengukuhan merupakan satu daripada sifat semulajadi tanah berzarah halus apabila dibebankan. Terangkan ciri-ciri dan kaedah menganggarkan TIGA (3) parameter utama pengukuhan tanah iaitu :-

- [i] Pre-Consolidation Pressure
Tekanan Pra-Pengukuhan Tanah
- [ii] Compressibility Index
Indeks Kebolehmampatan Tanah
- [iii] Coefficient of Consolidation
Pekali Pengukuhan

State the importance of each of the above parameters and explain how it can be used to solve a consolidation problem. Use diagram to enhance your explanation.

Nyatakan kepentingan setiap parameter di atas dan terangkan bagaimana ianya boleh digunakan untuk menyelesaikan permasalahan pengukuhan. Gunakan rajah untuk membantu anda membuat penjelasan.

[10 marks/markah]

- [b] The results shown in **Table 4** were obtained from a set of consolidation tests on clay specimen taken from a 5.2 m thick clay layer of a construction site. The clay layer is underlain and overlain by coarse sand.

*Keputusan ujian ditunjukkan di **Jadual 4** diperolehi dari satu set ujian pengukuhan ke atas satu spesimen tanah lempung yang diambil daripada lapisan tanah lempung setebal 5.2 m di suatu tapak bina. Tanah lempung tersebut dilapisi oleh lapisan pasir kasar di bahagian atas dan bawah.*

Table 4/ Jadual 4

Pressure/Tekanan (kN/m^2)	Void Ratio After The Test/ Nisbah Lompang Di Akhir Ujian
400	0.98
800	0.76

The initial thickness of the sample was 19.6 mm with a moisture content of 18%. The sample took 7 minutes to achieve 20% consolidation.

Tebal asal sampel adalah 19.6 mm dengan kandungan lembapan sebanyak 18%. Sampel ini mengambil masa selama 7 minit untuk mencapai 20 % pengukuhan.

- [i] Estimate the total consolidation settlement of the clay layer based on the information given in **Table 4**.

*Anggarkan jumlah pegenapan pengukuhan bagi lapisan tanah lempung berdasarkan maklumat yang diberikan dalam **Jadual 4**.*

[5 marks/markah]

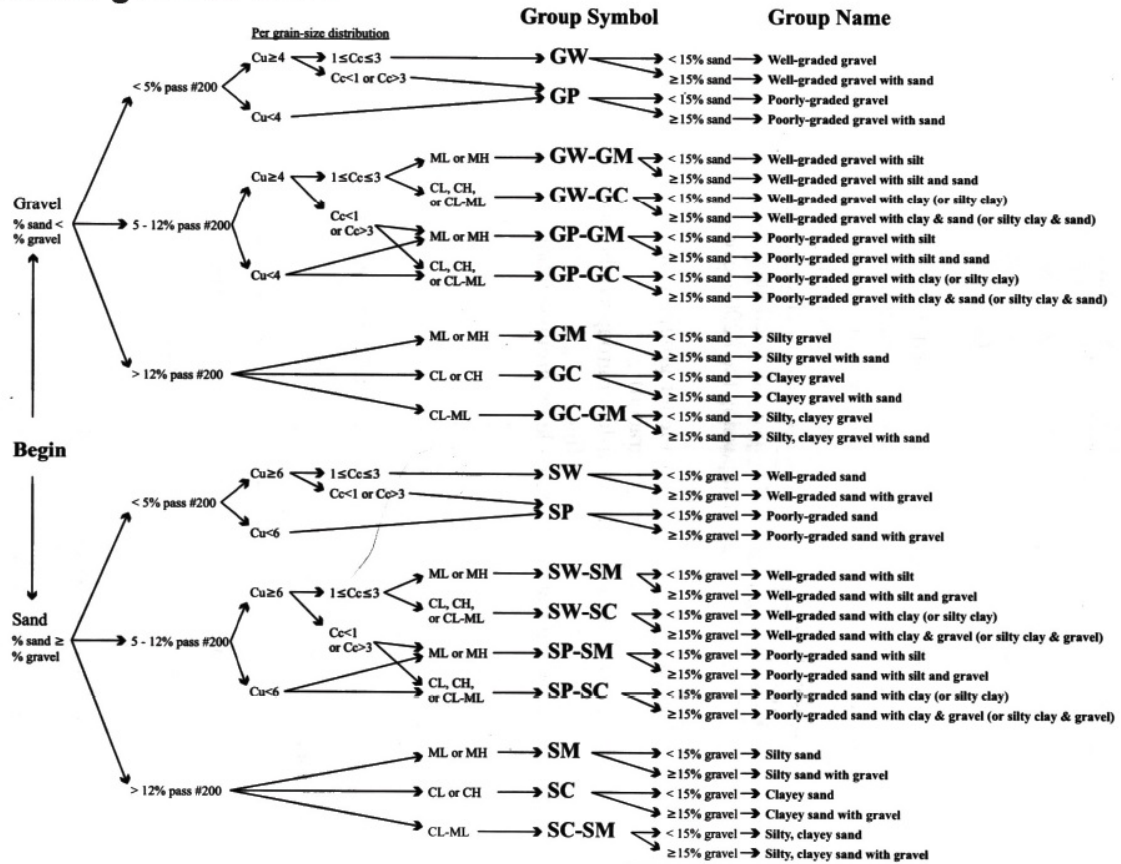
- [ii] Estimate the time to achieve 50% and 90% consolidation in the field and suggest a method to accelerate the consolidation process of the above clay layer. Use sketches to support your answers.

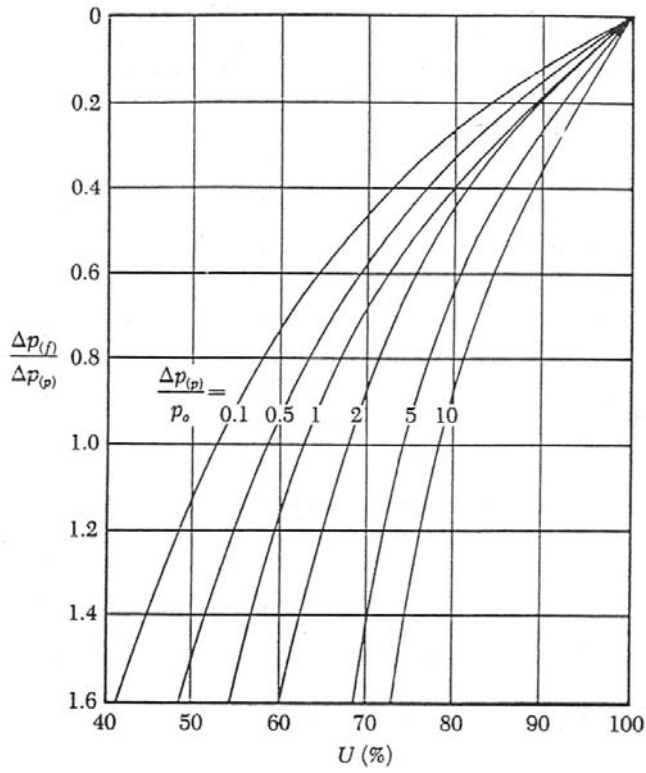
Anggarkan masa untuk mencapai 50% dan 90% pengukuhan di tapak dan cadangkan satu kaedah untuk mempercepatkan proses pengukuhan bagi lapisan tanah lempung di atas. Gunakan lakaran untuk menyokong jawapan anda.

[5 marks/markah]

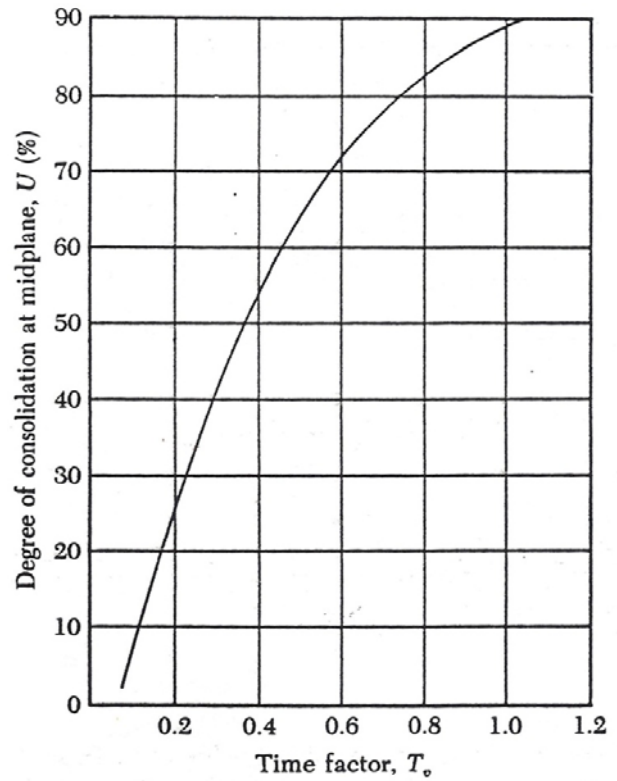
APPENDIX / LAMPIRAN

Coarse-grained Soils

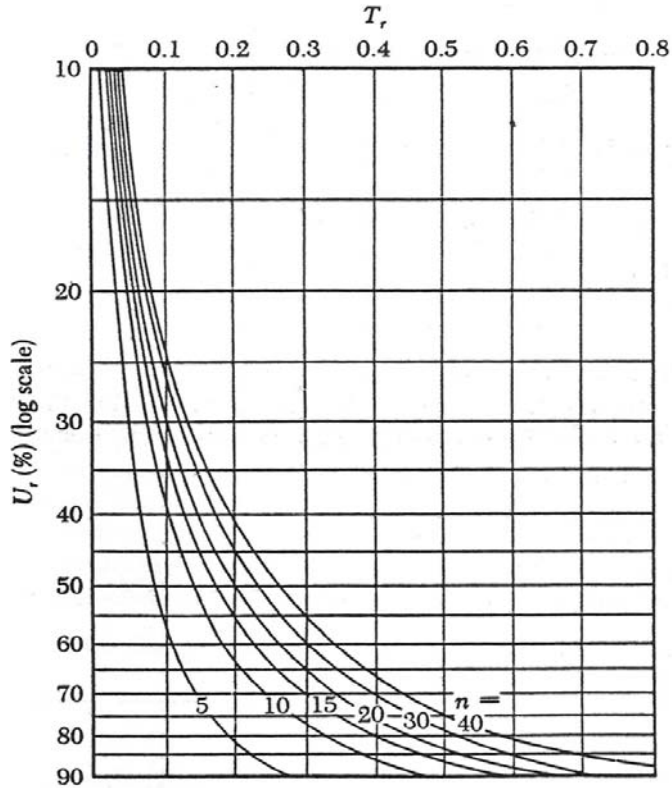




Plot of $\Delta p(f)/\Delta p(p)$ against U for various values of $\Delta p(p)/p_0$



Plot of midplane degree of consolidation against T_0



Average degree of consolidation for radial drainage only

-000000000-